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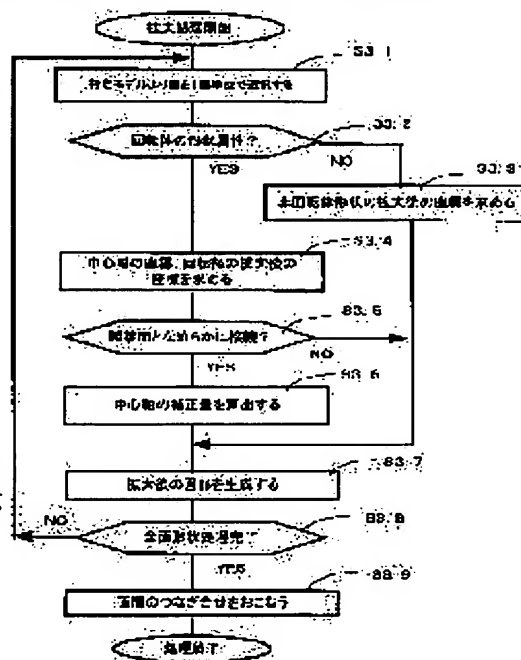
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(54) METHOD FOR REVERSE DEFORMATION AGAINST MOLDING SHRINKAGE IN MOLD DESIGN

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a method for reverse deformation against a molding shrinkage in a mold design which can improve the efficiency of the design and manufacture of a mold.

SOLUTION: In this method, the mold design is executed by using a CAD/CAM system equipped with a means for deformation which scales a three-dimensional model prepared by three-dimensional CAD, according to prescribed coefficients. The method has a first process of setting an enlargement ratio for the coordinate axes of X, Y and Z and for the arcuate radius of a rotating body, a second process wherein the shapes satisfying the shape conditions of a cylindrical surface and a conical surface of the rotating body are extracted from the objective three-dimensional model and are stored, a third process of applying a scaling deformation processing to the coordinate axes of X, Y and Z, a fourth process of extracting the shapes wherein the shape conditions of the cylindrical surface and the conical surface are not satisfied according to the scaling deformation processing in the third process, and a fifth process wherein shape correction is conducted for the shapes extracted in the fourth process so as to approximate them to the cylindrical surface and the conical surface.



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CLAIMS

[Claim(s)]

[Claim 1] In the design approach of performing a metal mold design using CAD/CAM equipment equipped with the deformation means which carries out zooming of the three-dimension model created by three dimensional CAD according to a predetermined multiplier X, Y, and Z -- with the 1st process which sets the dilation ratio to the diameter of radii of body of revolution as the dilation ratio list to each axis of coordinates The 2nd process which extracts and memorizes the configuration with which are satisfied of the configuration conditions of the cylinder side which is body of revolution, and a conical surface from the target three-dimension model, X, Y, and Z -- with the 3rd process which performs zooming deformation processing to each axis of coordinates The 4th process which extracts the configuration from which the configuration conditions of a cylinder side and a conical surface are no longer filled with zooming deformation processing of this 3rd process, The reverse deformation approach for the die shrinkage in the metal mold design characterized by having the 5th process which performs configuration amendment to the configuration extracted at this 4th process, and approximates a configuration to a cylinder side and a conical surface.

[Claim 2] In the case of the projection configuration or the hole configuration where a configuration from the first covers 360-degree perimeter range to a medial axis, and has the shape of a cylindrical shape, and a cone configuration in said 5th process X, Y, and Z -- with the process which carries out coordinate transformation using the predetermined dilation ratio to each axis of coordinates [in / in the coordinate of a center-of-rotation shaft / said 1st process] The reverse deformation approach for the die shrinkage in the metal mold design according to claim 1 characterized by having the process which carries out expansion processing using the dilation ratio to the predetermined diameter of body-of-revolution radii in the diameter of radii.

[Claim 3] It is the reverse deformation approach for the die shrinkage in the metal mold design according to claim 1 characterize by to have the process which amends the coordinate of the medial axis of a cylinder or a cone in order that after zooming deformation may hold the smooth connection relation when the connection relation between the process which inspects connection relation with a contact surface in said 5th process when a configuration from the first is [a cylinder or a cone configuration] a part , and a contact surface has touch smoothly .

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the reverse deformation approach for the die shrinkage in the metal mold design which carries out reverse deformation amendment especially in consideration of the die shrinkage of the resin ingredient at the time of injection molding about the design approach of designing the mold part shape for manufacturing this model by the injection molding die, from the three-dimension model created by three dimensional CAD.

[0002]

[Description of the Prior Art] Expansion model creation which multiplied by the inverse number of the molding shrinkage specified as the molding material list by the process condition and the product configuration as material data to the three-dimension model which expresses the given product configuration with the metal mold design approach using the conventional three dimensional CAD, and counted upon the contraction after shaping is performed. Since a product contracts by the forming process in which the resin which is a molding material carries out cooling solidification within metal mold, this is because it is necessary to make a metal mold dimension greatly by die shrinkage so that a product may be settled in a predetermined dimension after contraction.

[0003] Next, the solid model equivalent to the material of metal mold components is produced as a metal mold blank model, alignment of said expansion model is carried out to this metal mold blank model, and model data are piled up. furthermore, said blank model to an expansion model -- difference -- the product configuration section of calculating can generate the solid model used as a cavity as a metal mold geometry component.

[0004] Next, the parting plane of metal mold is set up to the lump of said metal mold geometry component, and, generally the procedure of performing a division design is used for the slide metal mold part shape of the direction of mold omission over fixed side metal mold components and movable side metal mold components, and each undercut section. It is effectively utilizable by metal mold design in a product model by producing the expansion model reverse-amended by die shrinkage with such a procedure to the product model modeled by three dimensional CAD.

[0005] The simple design technique of molding shrinkage of the directivity of a resin flow being disregarded, dealing with contraction as isotropy, and expanding uniformly with one contraction was common.

[0006] However, the case where it takes to the advancement of a dimensional accuracy demand of a product, and the differential shrinkage by the directivity (they are a perpendicular direction and the direction of board thickness to a flow direction and flow) of a resin flow cannot be disregarded is beginning to increase. In the engineering plastics by which the glass fiber, the carbon fiber, etc. were added in order to reform join character resin and the molding material physical properties which are especially represented by nylon, the anisotropy of contraction is remarkable especially. To these cases, contraction which became independent to each axis of coordinates of X, Y, and Z is set up, and the three-dimension model deformation technique into which change a dilation ratio into for every shaft, and a three-dimension model is made to reverse-transform is applied.

[0007] P_n' (X_n' , Y_n' , Z_n') can express the new coordinate after the reference point P_0 (X_0 , Y_0 , Z_0) at the time of carrying out expansion processing of the three-dimension model, and expansion processing of as opposed to [when one dilation ratio of each shaft of P_n (X_n , Y_n , Z_n), X, Y, and Z is set to S_x , S_y and S_z , respectively] P_1 of arbitration with the following formula.

[0008]

The relation between $X_n' = (X_n - X_0) * S_x - X_0 Y_n' = (Y_n - Y_0) * S_x - Y_0 Z_n' = (Z_n - Z_0) * S_x - Z_0$ in addition a dilation ratio, and contraction is expressed with a degree type.

[0009] Dilation ratio = $1/(1-\text{contraction})$

[0010]

[Problem(s) to be Solved by the Invention] However, by the conventional approach, in order to carry out coordinate count of the coordinate value of X, Y, and Z each shaft according to each dilation ratio and to transform a graphic form, in the case of a rotation configuration with medial axes, such as the shape of the shape of a cylindrical shape, a cone configuration, and a globular form, it will be in the condition that a shape property cannot be held as body of revolution. This condition is explained.

[0011] Drawing 1 is a configuration which has R beveling c in the configuration of 2mm of board thickness in the projection b of Hole a and a cone, and four corners. This is expanded using $S_x=1.1$, $S_y=2.0$, and $S_z=1.5$ as a dilation ratio of X, Y, and Z each shaft. However, the dilation ratio for which it asks from actual die shrinkage is explained here using a big value, in order to make change condition of a configuration intelligible also about 1.0-1.1, and the difference for every shaft orientations, although it is 0.0 to about 0.05.

[0012] here -- a hole -- a -- ' -- a projection -- b -- ' -- beveling -- c -- ' -- an ellipse -- having extruded -- a configuration -- becoming -- one -- a ** -- a medial axis -- receiving -- body of revolution -- ***** -- a shape property -- being lost . Specifically, the cross-section configuration of the diameter $\phi 10\text{mm}$ perfect circle of the hole a before expansion will deform into the ellipse of 20mm (Y-axis) of long sides, and 11mm of shorter sides (X-axis). Projection b and R beveling c become an ellipse similarly.

[0013] For this reason, when using an expansion model in the condition of this as, the following problem occurs in a design and manufacture of metal mold.

[0014] 1) The topographic contour plot side which projects and creates a three-dimension model becomes complicated. Dimension directions were easily possible for body of revolution, such as the shape of a usual cylindrical shape, for the coordinate value and circle diameter of a medial axis at drafting specification, such as JIS. However, to an elliptical part, the special drawing directions of directions of a long side and a shorter side etc. are needed, and there is a problem which worsens drafting effectiveness.

[0015] 2) Hole processing and contour milling become difficult. In hole processing, in cylindrical shape-like processing, it is easily processible by machining processing of a milling machine etc. using rotation tools, such as a drill and a reamer. However, in the case of an ellipsoid, the contour milling by the end mill is needed, and processing effectiveness gets worse. Furthermore, NC control machine more than coincidence biaxial will be needed, and the machine tool to be used will also narrow the selection range of a metal mold processing machine. Moreover, in the case of contour milling, in the case of-like [cylindrical shape], it can be managed with one circular interpolation command to an NC machine tool, but in the case of an ellipse profile, NC data which carried out division approximation are needed for a straight line or radii. For this reason, while the time amount which NC program activity for processing takes also increases, NC amount of data also has the problem of becoming huge.

[0016] As mentioned above, when using an expansion model as it is, there is a serious problem of worsening the working efficiency of a drafting process and a processing process remarkably. As a means of the present condition for preventing this, to the reverse deformation model by expansion processing, a metal mold designer will inspect rotation configurations, such as a hole, a projection, and a corner R part, using a three-dimensional-CAD function, the part which needs the shape property of body of revolution will once delete a configuration, and the activity of re-producing a model in a body-of-revolution configuration further will be done.

[0017] As mentioned above, when making the partial correction of the three-dimension model, it is a problem that it takes the time and effort which this takes, and time amount. in order to prevent these failures -- X, Y, and Z -- also when a dilation ratio which is different on each shaft is given and expansion deformation is carried out, the design approach which the body-of-revolution configuration sections, such as a cylinder, a cone, and a ball, hold the configuration attribute as rotation ****, and carries out expansion deformation is needed.

[0018] the place which this invention was made in view of the above-mentioned problem, and makes into the purpose -- X, Y, and Z -- when different contraction to each shaft is set up, it is in offer the reverse deformation approach for the die shrinkage in the metal mold design which can hold smooth connection relation with a contact surface in a cylinder and a conic body of revolution attribute list, and can raise the effectiveness of a metal mold design and manufacture.

[0019]

[Means for Solving the Problem] In the design approach of performing a metal mold design using CAD/CAM equipment equipped with the deformation means which carries out zooming of the three-dimension model with which this invention was created by three dimensional CAD in order to attain the above-mentioned purpose according to a predetermined multiplier X, Y, and Z -- with the 1st process which sets the dilation ratio to the diameter of radii of body of revolution as the dilation ratio list to each axis of coordinates The 2nd process which extracts and memorizes the configuration with which are satisfied of the configuration conditions of the cylinder side which is body of revolution, and a conical surface from the target three-dimension model, X, Y, and Z -- with the 3rd process which performs zooming deformation processing to each axis of coordinates In zooming deformation processing of this 3rd process, it is characterized by having the 4th process which extracts the configuration with which the configuration conditions of a cylinder side and a conical surface are no longer filled, and the 5th process which performs configuration amendment to the configuration extracted at this 4th process, and approximates a configuration to a cylinder side and a conical surface.

[0020]

[Embodiment of the Invention] The gestalt of operation of this invention is explained based on an accompanying drawing below.

[0021] Drawing 3 is the block diagram showing the configuration of the design equipment for enforcing this invention approach, and is set to this drawing. CRT whose 1 is CPU and whose 2 is a display means, and 3 The input sections, such as a keyboard and a mouse, ROM 4 has remembered the control program and the program of configuration data processing in the metal mold design of this invention to be, The data file which saves RAM where 5 stores various processing results temporarily, the three-dimension model which designed 6 by the mold-goods model beforehand produced with external equipment or this invention, and 7 are item files, and the parameter set up beforehand is registered.

[0022] 8 is a communication line and the CAD/CAM equipment 10 which performs a components design metallurgy die design is connected by LAN. 9 is a bus line. In storage lists, such as a FUROPI disk and CD-ROM, 11 is a storage and keeps the program of this invention.

[0023] Explanation of operation by design equipment equipped with the above configuration is given with reference to drawing 4 - drawing 12.

[0024] Drawing 4 is an outline flowchart which shows the design procedure in the reverse deformation approach for the die shrinkage in the metal mold design of this invention. By this approach, a three-dimension components model is displayed on the indicating equipment 2 of a certain mold components design equipment used by this invention, and the designer of metal mold chooses the model used as the expansion processing object for reverse deformation from the inside of the three-dimension model displayed at step S1 of drawing 4 with the input unit of mouse 3 grade first.

[0025] next, the step S2 -- X, Y, and Z -- the dilation ratios S_x , S_y , and S_z for every shaft -- the designer of metal mold specifies the dilation ratio S_r of the diameter of body of revolution with the input unit of keyboard 3 grade further. Moreover, the zero coordinate location $P_0 (X_0, Y_0, Z_0)$ at the time of expansion also specifies it as coincidence.

[0026] Based on the input data of steps S1-S2, CPU1 performs expansion processing at step 3 based on the coordinate operation of a model to an assignment model. Finally, by step 4, the reverse deformation model after expansion processing is displayed on CRT2, and processing is completed.

[0027] Next, an example of expansion processing of said step S3 is explained in detail using drawing 5.

[0028] First, the field which serves as an expansion processing object from an assignment model by step S3.1 is chosen per 1st page.

[0029] Next, step S3.2 performs the configuration classification of a view side. A view side is classified into surface of revolution with one center-of-rotation shaft, such as a cylinder side and a conical surface, and the general surface which is other nonrotation objects. In the case of surface of revolution, expansion processing of the body of revolution of steps S3.4-S3.6 is performed. Moreover, in the case of the other general surface, it becomes processing of step S3.4.

[0030] Drawing 6 is the example of a classification of a field. The field 1 of * mark in drawing - a field 7 are surface of revolution. The projection of the hole of a field 1 and the cone of fields 2-3 is an example from which surface of revolution is made to 360-degree perimeter to the revolving shaft. Fields 4-7 are the examples of the

field which consists of a part of surface of revolution. Moreover, the fields 8-13 of the-less mark are the general surface of a nonrotation side configuration.

[0031] Next, the coordinate after expansion of a nonrotation configuration is searched for by step S3.3.

[0032] Drawing 7 is the example showing one relation of each coordinate value of P' after Pn and expansion of arbitration, when the field which expanded the view side d is field d'. Pn' (Xn', Yn', Zn') can express the new coordinate after the reference point P0 (X0, Y0, Z0) at the time of carrying out expansion processing of the three-dimension model, and expansion processing of as opposed to [when one dilation ratio of each shaft of Pn (Xn, Yn, Zn), X, Y, and Z is set to Sx, Sy and Sz, respectively] Pn of arbitration with the following formula.

[0033]

HEJAMPU [processing] step S3.7 after asking for the coordinate data after $Xn'=(Xn-X0) * Sx-X0$ $Yn'=(Yn-Y0) * Sx-Y0$ $Zn'=(Zn-Z0) * Sx-Z0$ expansion.

[0034] Next, the processing to the surface of revolution of steps S3.4-S3.6 is explained.

[0035] First, the medial-axis list of surface of revolution is asked for the coordinate value after expansion of the diameter of rotation by step S3.4.

[0036] Drawing 8 is drawing explaining expansion processing of surface of revolution. The field e in drawing is the example of the surface of revolution used as the candidate for expansion. Field e is surface of revolution, the both-ends point of a revolving shaft and phiD are Ps(es) (Xs, Ys, Zs), and Pe (Xe, Ye, Ze) is a radius of gyration. Field e is changed into field e' by expansion processing, and, as for Ps, Pe, and phiD, P's (Xs', Ys', Zs'), P'e (Xe', Ye', Ze'), and phiD' corresponds, respectively. Transformation turns into a bottom type.

[0037]

Adjacency with a contact surface is investigated at $Xs'=(Xs-X0) * Sx-X0$ $Ys'=(Ys-Y0) * Sx-Y0$ $Zs'=(Zs-Z0) * Sx-Z0$ $Xe'=(Xe-X0) * Sx-X0$ $Ye'=(Ye-Y0) * Sx-Y0$ $Ze'=(Ze-Z0) * Sx-Z0$ $phiD' = phiD * Sr$, next step S3.5. In the case of the conditions connected smoothly, step S3.6 is processed. Moreover, HEJAMPU step S3.7 when not fulfilling conditions.

[0038] Drawing 9 is an example connected smoothly. Field f has a common tangential plane on a field boundary to a contact surface h. Field f has smooth connection conditions to Field g similarly.

[0039] Next, step S3.6 amends the coordinate of a center-of-rotation shaft.

[0040] Drawing 10 is drawing for explaining the need for stem correction. The model configuration of drawing 10 is drawing which looked at drawing 9 from XY flat surface.

[0041] The target field f is body of revolution with a medial axis Lc (the coordinates in each XY flat surface are Xc and Yc, and are segments parallel to the Z-axis), and has connected contact surfaces h and g smoothly. here -- X -- Y -- each -- shaft orientations -- a dilation ratio -- Sx -- Sy -- or -- rotation -- a path -- receiving -- a dilation ratio -- all -- being the same -- a value -- it is not -- a case -- setting -- expansion -- the back -- a field -- f -- ' -- the smooth connection relation between contact surface h' after expansion, and g' -- collapsing . in addition -- although it is a reference configuration -- fe in drawing -- radii -- XY shaft -- it is a configuration at the time of expanding unequally and carrying out ellipse conversion. Elliptical has a problem on drafting and metal mold processing as mentioned above, and makes conversion to elliptical improper in this invention. For this reason, after expansion deformation maintains smooth adjacency from the first, and in this example, a medial axis is amended so that the cross-section configuration in XY flat surface may serve as radii.

[0042] Drawing 11 is the example of amendment of a medial axis. drawing -- inside -- a contact surface -- h -- g -- expansion -- conversion -- the back -- a field -- h -- ' -- g -- ' -- from -- expansion -- the back -- a radius of gyration -- R -- ' -- having offset -- a field -- h -- " -- g -- " -- an intersection -- L"C -- amendment -- the back -- a medial axis -- ** -- carrying out -- radius-of-gyration R' -- surface of revolution -- rewriting .

[0043] Above, expansion processing of the field for one to which its attention was paid is completed.

[0044] Furthermore, HEJAMPU [it inspects whether expansion processing was performed to the whole surface of a selection model by step S3.8, and] step S3.9 when there is an unsettled side and the whole surface is completed to step S3.1.

[0045] A field configuration connects step S3.9 and it is doubling processing. In processing to the aforementioned steps S3.1-S3.7, since expansion processing has been performed per 1st page of view, the crossover and clearance between contact surface coincidence occur. By extending or contracting contact surface coincidence, eye ** is performed for a clearance and the configuration of a three-dimension model is prepared.

[0046] the above step -- X, Y, and Z -- even when the dilation ratio of a different value to each shaft is set up,

while holding the shape property of body of revolution to body of revolution, it becomes producible [the reverse deformation model holding connection relation with a contact surface].

[0047]

[Effect of the Invention] In the design approach of performing a metal mold design using CAD/CAM equipment equipped with the deformation means which carries out zooming of the three-dimension model created by three dimensional CAD according to a predetermined multiplier by the above explanation according to this invention so that clearly X, Y, and Z -- with the 1st process which sets the dilation ratio to the diameter of radii of body of revolution as the dilation ratio list to each axis of coordinates The 2nd process which extracts and memorizes the configuration with which are satisfied of the configuration conditions of the cylinder side which is body of revolution, and a conical surface from the target three-dimension model, X, Y, and Z -- with the 3rd process which performs zooming deformation processing to each axis of coordinates The 4th process which extracts the configuration from which the configuration conditions of a cylinder side and a conical surface are no longer filled with zooming deformation processing of this 3rd process, Since it had the 5th process which performs configuration amendment to the configuration extracted at this 4th process, and approximates a configuration to a cylinder side and a conical surface, X, Y, and Z -- when different contraction to each shaft is set up, the effectiveness that smooth connection relation with a contact surface can be held in a cylinder and a conic body-of-revolution attribute list, and the effectiveness of a metal mold design and manufacture can be raised to them is acquired.

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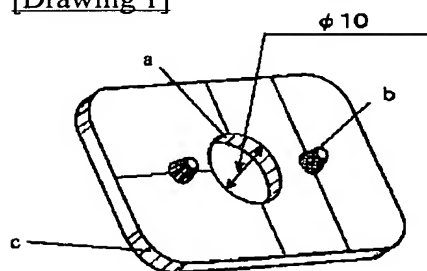
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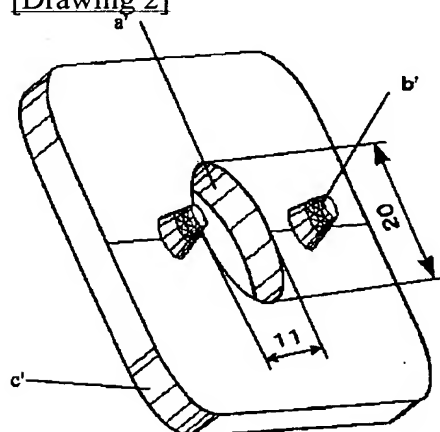
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DRAWINGS

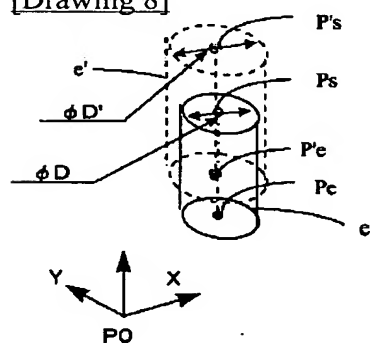
[Drawing 1]



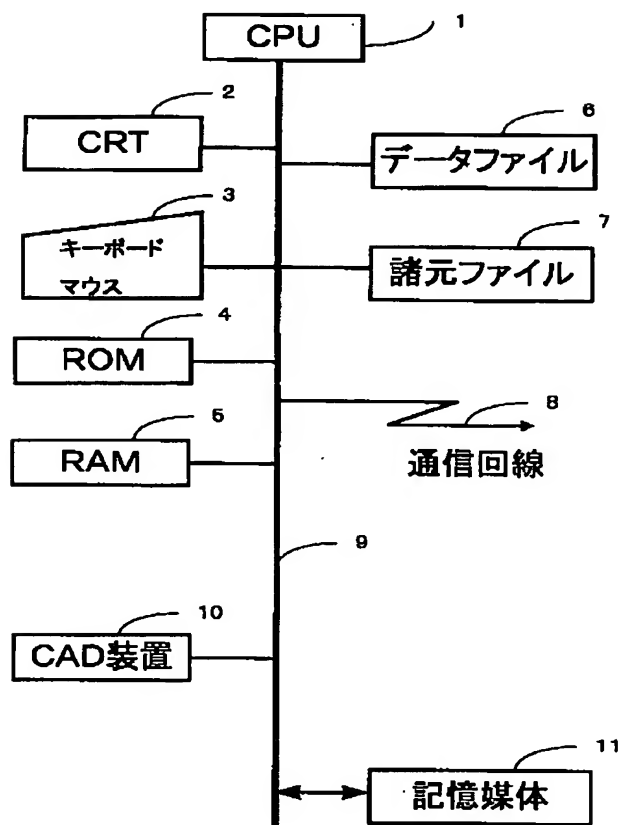
[Drawing 2]



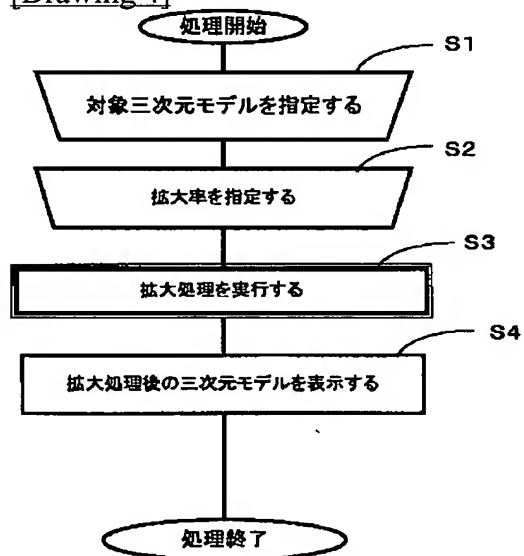
[Drawing 8]



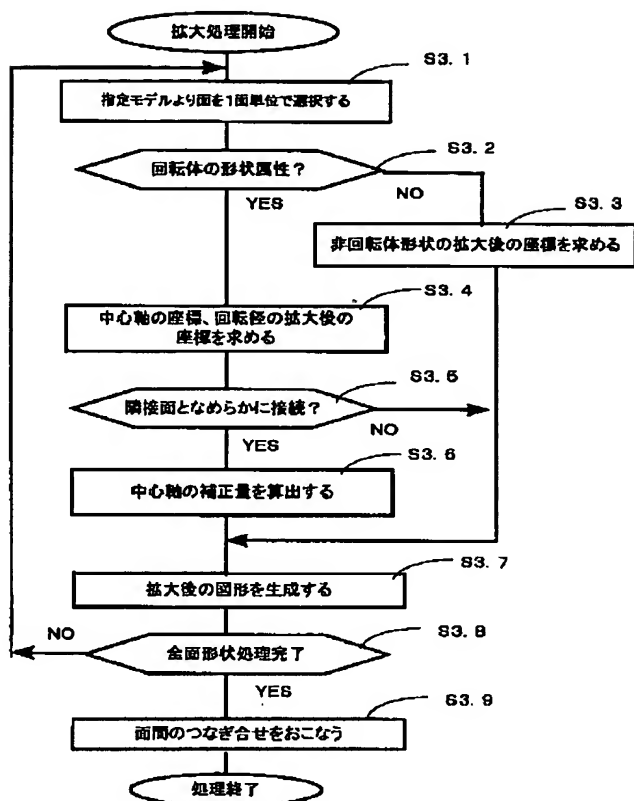
[Drawing 3]



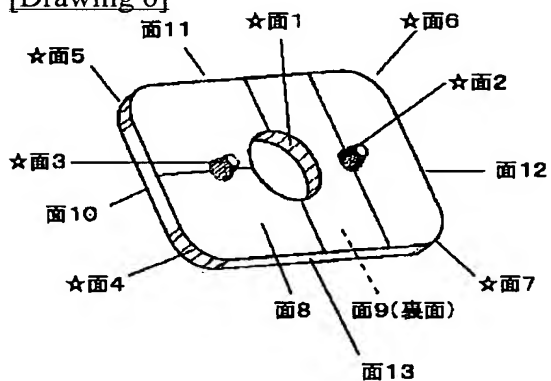
[Drawing 4]



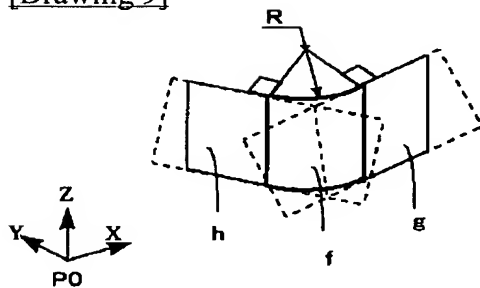
[Drawing 5]



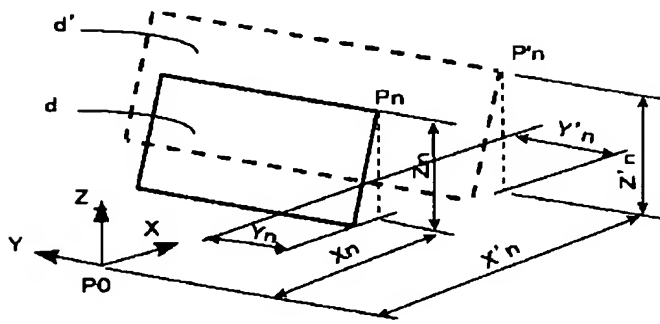
[Drawing 6]



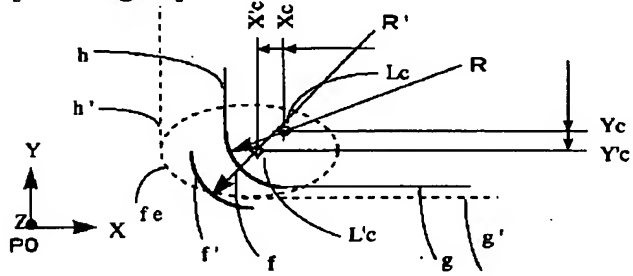
[Drawing 9]



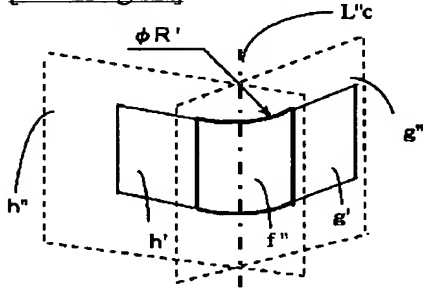
[Drawing 7]



[Drawing 10]



[Drawing 11]



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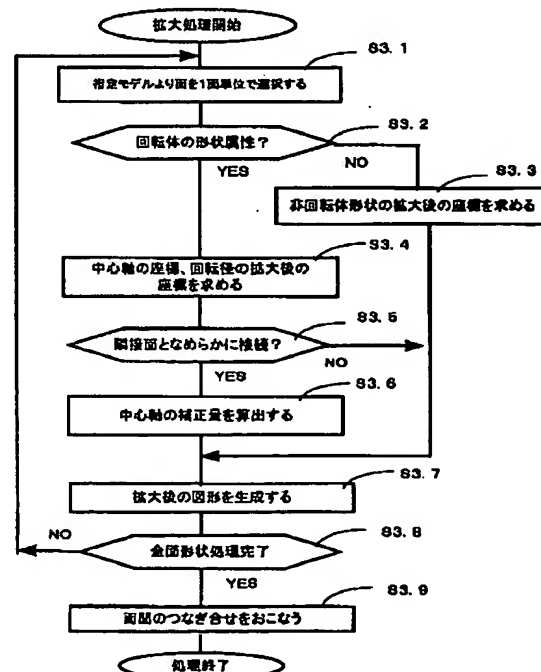
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(54)【発明の名称】 金型設計における成形収縮に対する逆変形方法

(57)【要約】

【目的】 金型設計・製作の効率を向上させることができる金型設計における成形収縮に対する逆変形方法を提供すること。

【構成】 3次元CADで作成された3次元モデルを所定の係数に従って拡大・縮小する変形手段を備えるCAD/CAM装置を用い金型設計を行う設計方法において、X、Y、Zそれぞれの座標軸に対する拡大率並びに回転体の円弧径に対する拡大率を設定する第1の工程と、対象となる3次元モデルから回転体である円筒面及び円錐面の形状条件を満足する形状を抽出して記憶する第2の工程と、X、Y、Zそれぞれの座標軸に対して拡大・縮小変形処理を施す第3の工程と、該第3の工程の拡大・縮小変形処理では円筒面と円錐面の形状条件が満たされなくなる形状を抽出する第4の工程と、該第4の工程で抽出された形状に対して形状補正を行い円筒面と円錐面に形状を近似する第5の工程とを備える。



【特許請求の範囲】

【請求項1】 3次元CADで作成された3次元モデルを所定の係数に従って拡大・縮小する変形手段を備えるCAD/CAM装置を用い金型設計を行う設計方法において、

X、Y、Zそれぞれの座標軸に対する拡大率並びに回転体の円弧径に対する拡大率を設定する第1の工程と、対象となる3次元モデルから回転体である円筒面及び円錐面の形状条件を満足する形状を抽出して記憶する第2の工程と、X、Y、Zそれぞれの座標軸に対して拡大・縮小変形処理を施す第3の工程と、該第3の工程の拡大・縮小変形処理では円筒面と円錐面の形状条件が満たされなくなる形状を抽出する第4の工程と、該第4の工程で抽出された形状に対して形状補正を行い円筒面と円錐面に形状を近似する第5の工程とを備えたことを特徴とする金型設計における成形収縮に対する逆変形方法。

【請求項2】 前記第5の工程において元々の形状が中心軸に対して360°全周範囲に亘って円筒形状又は円錐形状を持つ突起形状又は穴形状の場合においては、回転中心軸の座標は前記第1の工程におけるX、Y、Zそれぞれの座標軸に対する所定の拡大率を用いて座標変換する工程と、円弧径においては所定の回転体円弧径に対する拡大率を用いて拡大処理する工程とを備えたことを特徴とする請求項1記載の金型設計における成形収縮に対する逆変形方法。

【請求項3】 前記第5の工程において、元々の形状が円筒又は円錐形状が一部の場合においては、隣接面との接続関係を検査する工程と、隣接面との接続関係が滑らかに接している場合は、拡大・縮小変形後もその滑らかな接続関係を保持するため円筒又は円錐の中心軸の座標を補正する工程とを備えたことを特徴とする請求項1記載の金型設計における成形収縮に対する逆変形方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】 本発明は、3次元CADで作成された3次元モデルから該モデルを射出成形用金型で製作するためのモールド部品形状を設計する設計方法に関し、特に射出成形時の樹脂材料の成形収縮を考慮して逆変形補正する金型設計における成形収縮に対する逆変形方法に関するものである。

【0002】

【従来の技術】 従来の3次元CADを用いた金型設計方法では、与えられた製品形状を表す3次元モデルに対して成形材料並びに成形条件と製品形状によって材料データとして指定されている成形収縮率の逆数を乗じて成形後の収縮を見込んだ拡大モデル作成を行う。これは成形材料である樹脂が金型内で冷却固化する成形過程で製品が収縮するため、収縮後に製品が所定の寸法に収まるように金型寸法を成形収縮分だけ大きく作る必要があるためである。

【0003】 次に、金型部品の素材に相当するソリッドモデルを金型ブランクモデルとして作製し、前記拡大モデルをこの金型ブランクモデルに位置合わせしてモデルデータ同士を重ね合わせる。更に、前記ブランクモデルから拡大モデルを差分演算することでの製品形状部が空洞となったソリッドモデルを金型形状部品として生成することができる。

【0004】 次に、前記金型形状部品の塊に対して金型の分割面を設定し、固定側金型部品及び可動側金型部品とそれぞれのアンダーカット部に対する型抜き方向のスライド金型部品形状に分割設計を行う手順が一般的に用いられている。このような手順により、3次元CADでモデル化された製品モデルに対して、成形収縮分だけ逆補正した拡大モデルを作製することによって製品モデルを金型設計で有効に活用を行うことができる。

【0005】 成形収縮率は、樹脂流動の方向性を無視して収縮を等方性として取り扱い、1つの収縮率で一律拡大するという簡略設計手法が一般的であった。

【0006】 ところが、製品の寸法精度要求の高度化に連れて樹脂流動の方向性（流れ方向、流れに垂直方向、板厚方向）による収縮差が無視できないケースが増加し始めている。特に、ナイロンに代表される結晶性樹脂や成形材料物性を改質するためにガラス繊維や炭素繊維等が添加されたエンジニアリングプラスチックでは、特に収縮の異方性が顕著である。これらのケースに対しては、X、Y、Zの各座標軸に対して独立した収縮率を設定し、軸毎に拡大率を変えて3次元モデルを逆変形させる3次元モデル変形技術が適用されている。

【0007】 3次元モデルを拡大処理する際の基準点P0(X0, Y0, Z0)、任意の1点Pn(Xn, Yn, Zn)、X、Y、Zの各軸の拡大率をそれぞれSx、Sy、Szとすると、P1に対する拡大処理後の新たな座標はPn'(Xn', Yn', Zn')は下記の式で表すことができる。

【0008】

$$Xn' = (Xn - X0) * Sx - X0$$

$$Yn' = (Yn - Y0) * Sy - Y0$$

$$Zn' = (Zn - Z0) * Sz - Z0$$

尚、拡大率と収縮率の関係は次式で表される。

$$【0009】 \text{拡大率} = 1 / (1 - \text{収縮率})$$

【0010】

【発明が解決しようとする課題】 しかしながら、従来の方法では、X、Y、Z各軸の座標値をそれぞれの拡大率に応じて座標計算して図形を変形するため、円柱形状、円錐形状、球形状等の中心軸を持つ回転形状の場合は、回転体として形状特性が保持できない状態になる。この状態について説明する。

【0011】 図1は板厚2mmの形状に穴a、円錐の突起b、4隅にR面取りcを持つ形状である。これを、X、Y、Z各軸の拡大率として、Sx=1.1、Sy=

2. 0、 $S_z = 1.5$ を用いて拡大する。但し、実際の成形収縮から求める拡大率は、1.0～1.1、軸方向毎の差異に関しても0.0～0.05程度であるが、形状の変化具合を分かり易くするため、ここでは大きな値を用いて説明する。

【0012】ここで、穴 a' 、突起 b' 、面取り c' は楕円を押し出した形状となり、1つ中心軸に対する回転体としての形状特性がなくなってしまう。具体的には、拡大前の穴 a の直径 $\phi 10\text{mm}$ の真円の断面形状は、長辺(Y軸)20mm、短辺(X軸)11mmの楕円に変形されてしまう。同様に突起 b 、R面取り c も楕円となる。

【0013】このため、このままの状態では拡大モデルを利用する場合においては、金型の設計・製作において下記の問題が発生する。

【0014】1) 3次元モデルを投影して作成する二次元図面が複雑になる。通常の円柱形状等の回転体は、中心軸の座標値及び円直径でJIS等の製図規格で容易に寸法指示が可能であった。しかし、楕円形状部分に対しては長辺と短辺の指示等、特殊な図面指示が必要となり、製図効率を悪化させる問題がある。

【0015】2) 穴加工、輪郭加工が困難になる。円柱形状加工において、穴加工の場合はドリル、リーマ等の回転工具を用いてフライス盤等の工作加工で容易に加工できる。しかし、楕円体の場合は、エンドミルによる輪郭加工が必要となり、加工効率が悪化する。更に、使用する工作機械も同時2軸以上のNC制御機械が必要になり、金型加工機械の選択範囲を狭めることになる。又、輪郭加工の場合においても、円筒形状の場合はNC工作機械に対して1つの円弧補間指令で済むが、楕円輪郭の場合は、直線若しくは円弧に分割近似したNCデータが必要になる。このため、加工用NCプログラム作業に要する時間も増大するとともに、NCデータ量も膨大になるという問題がある。

【0016】以上のように、拡大モデルをそのまま利用する場合は、製図工程、加工工程の作業効率を著しく悪化させるという重大な問題がある。これを防止するための現状の手段としては、拡大処理による逆変形モデルに対して、穴、突起、隅R部分等の回転形状を金型設計者が3次元CAD機能を用いて検査を行い、回転体の形状特性が必要な箇所は形状を一旦削除し、更にモデルを回転体形状に再作製するという作業を行うことになる。

【0017】以上のように、3次元モデルを部分修正する場合は、これに要する手間と時間が掛かることが問題である。これらの障害を防止するためには、X、Y、Zそれぞれの軸に異なる拡大率を与えて拡大変形させた場合も、円柱、円錐、球等の回転体形状部は回転体としての形状属性を保持して拡大変形させる設計方法が必要となる。

【0018】本発明は上記問題に鑑みてなされたもの

で、その目的とする処は、X、Y、Zそれぞれの軸に対して異なる収縮率が設定された場合においても、円柱及び円錐の回転体属性並びに隣接面との滑らかな接続関係を保持して金型設計・製作の効率を向上させることができる金型設計における成形収縮に対する逆変形方法を提供することにある。

【0019】

【課題を解決するための手段】上記目的を達成するため、本発明は、3次元CADで作成された3次元モデルを所定の係数に従って拡大・縮小する変形手段を備えるCAD/CAM装置を用いて金型設計を行う設計方法において、X、Y、Zそれぞれの座標軸に対する拡大率並びに回転体の円弧径に対する拡大率を設定する第1の工程と、対象となる3次元モデルから回転体である円筒面及び円錐面の形状条件を満足する形状を抽出して記憶する第2の工程と、X、Y、Zそれぞれの座標軸に対して拡大・縮小変形処理を施す第3の工程と、該第3の工程の拡大・縮小変形処理では円筒面と円錐面の形状条件が満たされなくなる形状を抽出する第4の工程と、該第4の工程で抽出された形状に対して形状補正を行い円筒面と円錐面に形状を近似する第5の工程とを備えたことを特徴とする。

【0020】

【発明の実施の形態】以下に本発明の実施の形態を添付図面に基いて説明する。

【0021】図3は本発明方法を実施するための設計装置の構成を示すブロック図であり、同図において、1はCPU、2は表示手段であるCRT、3はキーボード及びマウス等の入力部、4は制御プログラムや本発明の金型設計における形状データ処理のプログラムを記憶しているROM、5は各種処理結果を一時記憶するRAM、6は予め外部の装置で作製された成形品モデルや本発明で設計した3次元モデル等を保存するデータファイル、7は諸元ファイルであり、予め設定されたパラメータが登録されている。

【0022】8は通信回線であり、部品設計や金型設計を行うCAD/CAM装置10がLANにより接続されている。9はバスラインである。11はフロッピーディスク、CD-ROM等の記憶装置並びに記憶媒体であり、本発明のプログラムの保管を行う。

【0023】以上の構成を備える設計装置による動作説明を図4～図12を参照して行う。

【0024】図4は本発明の金型設計における成形収縮に対する逆変形方法における設計手順を示す概略フローチャートである。この方法では、本発明で使用する或るモールド部品設計装置の表示装置2へ3次元部品モデルを表示し、先ず図4のステップS1で、表示された3次元モデルの中より逆変形のための拡大処理対象となるモデルをマウス3等の入力装置で金型の設計者が選択する。

【0025】次に、ステップS2により、X、Y、Zそれぞれの軸毎の拡大率 S_x 、 S_y 、 S_z 、更に回転体径の拡大率 S_r をキーボード3等の入力装置で金型の設計者が指定する。又、拡大時の原点座標位置 $P_0(X_0, Y_0, Z_0)$ も同時に指定を行う。

【0026】ステップS1～S2の入力データに基づいて、ステップ3では、指定モデルに対してCPU1によりモデルの座標演算に基づいて拡大処理を行う。最後にステップ4により、拡大処理後の逆変形モデルをCRT2に表示して処理を完了する。

【0027】次に、図5を用いて前記ステップS3の拡大処理の一例を詳しく説明する。

【0028】先ず、ステップS3.1により指定モデルより拡大処理対象となる面を1面単位で選択する。

【0029】次に、ステップS3.2により、着目面の形状分類を行う。着目面は、1つの回転中心軸を持つ円筒面、円錐面等の回転面とその他の非回転面である一般面に分類される。回転面の場合はステップS3.4～S3.6の回転体の拡大処理を実行する。又、その他の一般面の場合はステップS3.4の処理となる。

【0030】図6は面の分類例である。図中の☆印の面1～面7は回転面である。面1の穴、面2～3の円錐の突起は回転軸に対して360°全周に対して回転面が作られている事例である。面4～7は、回転面の一部で構成される面の例である。又、無印の面8～13は非回転面形状の一般面である。

【0031】次に、ステップS3.3により非回転形状の拡大後の座標を求める。

【0032】図7は着目面dを拡大した面が面d'の場合において任意の1点 P_n と拡大後の P' の各座標値の関係を表した例である。3次元モデルを拡大処理する際の基準点 $P_0(X_0, Y_0, Z_0)$ 、任意の1点 $P_n(X_n, Y_n, Z_n)$ 、X、Y、Zの各軸の拡大率をそれぞれ S_x 、 S_y 、 S_z とすると、 P_n に対する拡大処理後の新たな座標は $P_n'(X_n', Y_n', Z_n')$ は下記の式で表すことができる。

【0033】

$$X_n' = (X_n - X_0) * S_x - X_0$$

$$Y_n' = (Y_n - Y_0) * S_y - Y_0$$

$$Z_n' = (Z_n - Z_0) * S_z - Z_0$$

拡大後の座標データを求めた後、処理はステップS3.7へジャンプする。

【0034】次に、ステップS3.4～S3.6の回転面に対する処理について説明する。

【0035】先ず、ステップS3.4により回転面の中心軸並びに回転径の拡大後の座標値を求める。

【0036】図8は回転面の拡大処理を説明する図である。図中の面eは拡大対象となる回転面の例である。面eは回転面であり、 $P_s(X_s, Y_s, Z_s)$ 、 $P_e(X_e, Y_e, Z_e)$ は回転軸の両端点、 ϕD は回転半

径である。面eは拡大処理により面e'に変換され、 P_s 、 P_e 、 ϕD はそれぞれ、 $P'_s(X'_s, Y'_s, Z'_s)$ 、 $P'_e(X'_e, Y'_e, Z'_e)$ 、 $\phi D'$ が対応する。変換式は下式となる。

【0037】

$$X'_s = (X_s - X_0) * S_x - X_0$$

$$Y'_s = (Y_s - Y_0) * S_y - Y_0$$

$$Z'_s = (Z_s - Z_0) * S_z - Z_0$$

$$X'_e = (X_e - X_0) * S_x - X_0$$

$$Y'_e = (Y_e - Y_0) * S_y - Y_0$$

$$Z'_e = (Z_e - Z_0) * S_z - Z_0$$

$$\phi D' = \phi D * S_r$$

次に、ステップS3.5で隣接面との隣接関係を調べる。滑らかに接続する条件の場合はステップS3.6の処理を行う。又、条件を満たさない場合は、ステップS3.7へジャンプする。

【0038】図9は滑らかに接続する例である。面fは隣接面hに対して面境界上で共通の接平面を持つ。同様に面fは面gに対しても滑らかな接続条件を持つ。

【0039】次に、ステップS3.6により回転中心軸の座標の補正を行う。

【0040】図10は軸補正の必要性を説明するための図である。図10のモデル形状は図9をXY平面から見た図である。

【0041】対象となる面fは中心軸 L_c （それぞれのXY平面における座標は X_c 、 Y_c であり、Z軸に平行な線分）を持つ回転体であり、隣接面h、gとは滑らかに接続している。ここで、X、Yそれぞれの軸方向の拡大率 S_x 、 S_y 若しくは回転径に対する拡大率が全て同じ値でない場合においては、拡大後の面f'は拡大後の隣接面h'、g'との滑らかな接続関係が崩れる。尚、参考形状であるが、図中のfeは、円弧をXY軸不均等に拡大して楕円変換した場合の形状である。楕円形状は前述のように製図上及び金型加工上の問題があり、本発明では楕円形状への変換を不可としている。このため、拡大変形後も元々の滑らかな隣接関係を保ち、この例ではXY平面での断面形状が円弧となるように中心軸を補正する。

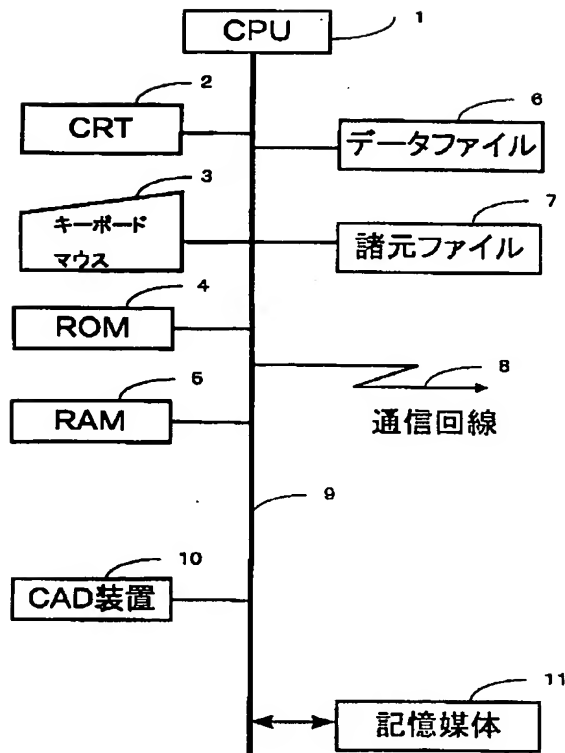
【0042】図11は中心軸の補正例である。図中の隣接面h、gの拡大変換後の面h'、g'から拡大後の回転半径 R' をオフセットした面h''、g''の交線 L''_C を補正後の中心軸とし、回転半径 R' で回転面を書き直す。

【0043】以上で、着目した1対象面の拡大処理を完了する。

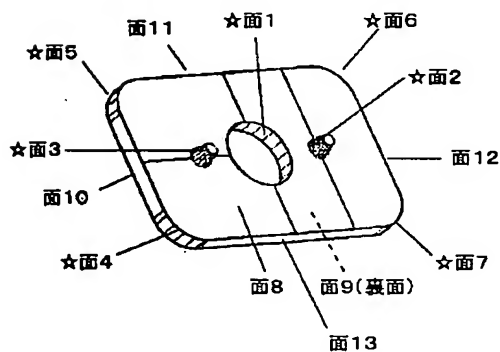
【0044】更に、ステップS3.8により選択モデルの全面に対して拡大処理が実行されたかを検査し、未処理面がある場合はステップS3.1へ、全面が終了した場合はステップS3.9へジャンプする。

【0045】ステップS3.9は、面形状の繋ぎ合せ処

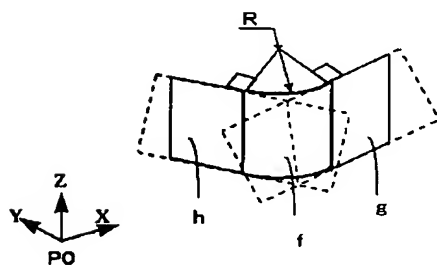
【図3】



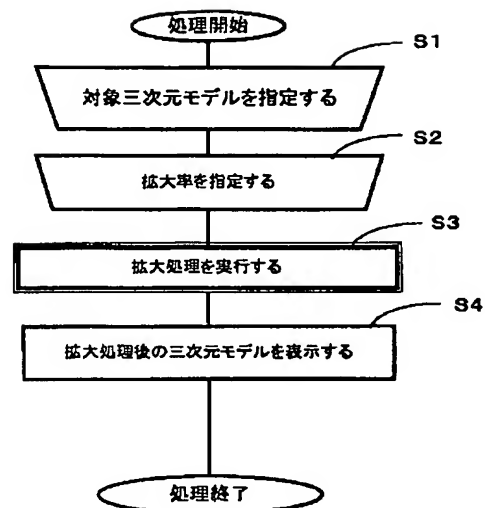
【図6】



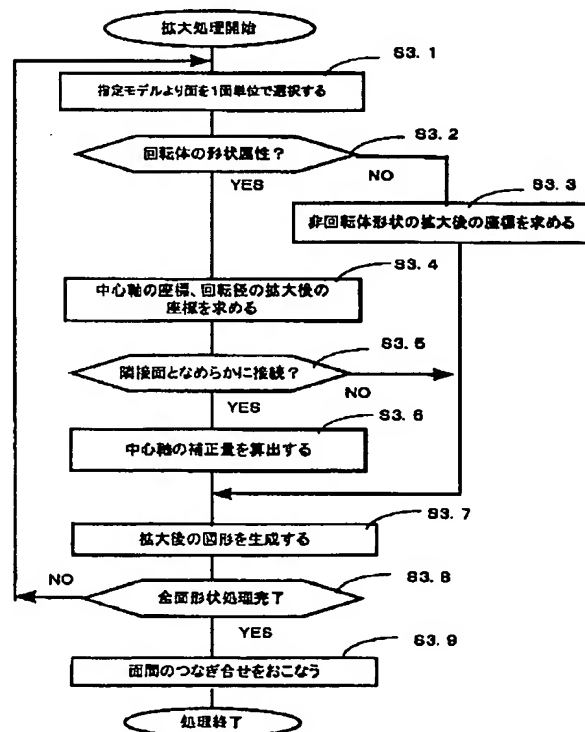
【図9】



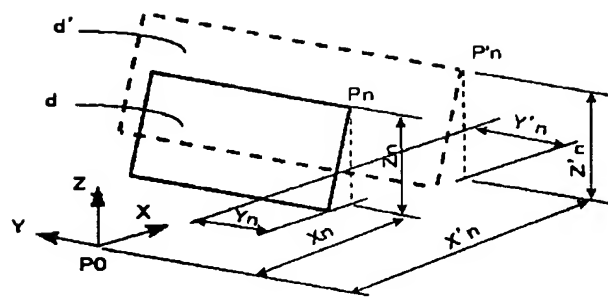
【図4】



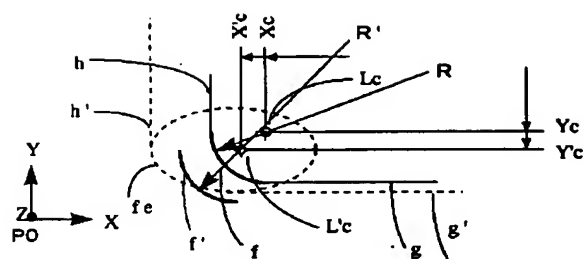
【図5】



【図 7】



【図 10】



【図 11】

